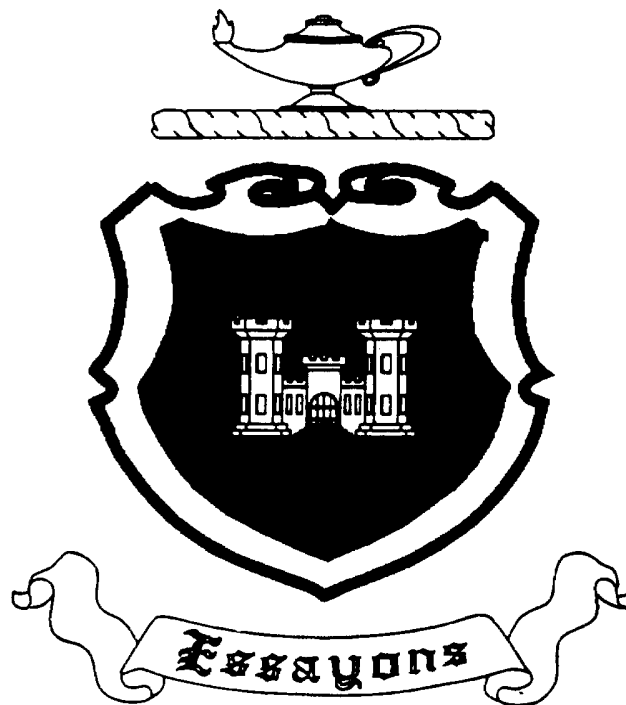# US ARMY ENGINEER CENTER AND SCHOOLS

CONSTRUCTION MANAGEMENT

Essayons

"LET US TRY"

THE ARMY INSTITUTE FOR PROFESSIONAL DEVELOPMENT

ARMY CORRESPONDENCE COURSE PROGRAM

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READINESS /
PROFESSIONALISM

THRU
GROWTH

Construction Management

Subcourse Number EN0375

Edition B

United States Army Engineer School
Fort Leonard Wood, MO 65473

19 Credit Hours

Edition Date: September 1992

Subcourse Overview

This subcourse presents a survey of the functions of management, the principles governing the functions and their ability to apply them to construction management. An understanding of these factors and the ability to apply them to construction projects is essential to the engineer company commander and the members of the battalion staff.

Also included in the subcourse are lessons on the use and application of the Critical Path Method (CPM) as it applies to military construction operations. What is taught about CPM should give you a good foundation for its use. You will, however, gain proficiency only through practical experience.

There are no prerequisites for this subcourse.

This subcourse reflects current doctrine when this subcourse was prepared. In your own work, always refer to the latest publications.

The words "he", 'him", "his", and "men", when used in this publication, represents the masculine and feminine genders unless otherwise stated.

TERMINAL LEARNING OBJECTIVES

ACTION: Identify the managerial functions to be performed by an engineer officer serving in command and staff positions.

CONDITION: Given the material contained in this subcourse.

STANDARD: To demonstrate proficiency you must attain a minimum score of 70 percent on the examination at the end of this subcourse.

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Use the above Publication Extracts to take this subcourse. At the time the subcourse was written, this was the current publication. In your own work situation, always refer to the latest publications.

Student Inquiry Sheet..

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Lesson 1

Functions of Management

Overview

<u>Lesson Description:</u>

This lesson addresses general military construction management techniques and how they are applied in the theater of operations.

<u>Learning Objective:</u>

<u>Action:</u>   Identify the general functions of management and how you can apply them to construction management.

<u>Condition:</u>   Given the material in this lesson.

<u>Standard:</u>   Correctly answer all practice exercise questions at the end of the lesson.

<u>Reference:</u>   The material contained in this lesson was derived from FM 5-333.

Introduction

Engineer construction functions in the theater of operations (TO) are the design, construction, repair, rehabilitation and maintenance of structures. These structures are roads, bridges, inland waterways, ports, industrial facilities, logistic support facilities, storage and maintenance areas, protective emplacements, hospital, camps, training areas, housing, administrative space and utilities. Other functions are the design, construction, and rehabilitation of railroads, airfields and heliports.

LESSON 1

FUNCTIONS OF MANAGEMENT

CREDIT HOURS..3

TEXT ASSIGNMENT..Chapter 1, FM 533.

MATERIALS REQUIRED...None.

EXERCISES

Requirement. Solve the following multiple-choice exercises.

1. The theater army commander establishes construction policies, standards, and priorities in accordance with base development plans, through the recommendations of

a. G-3

b. theater army engineer

c. Chief of Engineers

d. theater army support command engineer

2. Construction in the theater of operations is based on five principles. Which item listed below is NOT one of these principles?

a. decentralization of authority

b. flexibility

c. use of indigenous personnel

d. speed

3. Planning is the art of laying out a prospective project in advance. It serves the manager by pointing out which of the following?

a. who is responsible for what

b. where the work will be accomplished

c. when the work will be inspected

d. whether or not specifications for the Job will be met

4. Planning involves selection of objectives, policies, procedures and programs. The core of the manager's job in planning is

a. leading

b. advising

c. coordinating

d. decision-making

5. Organization involves the structural relationships by which an enterprise is bound together and the framework in which individual efforts are coordinated. The key to organization is

a. logic

b. selection of key personnel

c. centralization of authority

d. delegation of authority

6. Staffing entails finding the right man for the job. Problems which arise from limited personnel are solved through

a. planning and coordination of manpower assignments

b. reducing the scope of the project

c. lengthening the duration of the project

d. requesting augmentation of manpower from other sources

7. Directing embraces the practical problems of getting personnel to work as a team to accomplish the unit objective. Basically, it concerns managing human behavior and taking such action as will Improve

a. training   **c.** morale

b. performance   **d.** motivation

8. Control is defined as

a. staffing a project with sufficient personnel

b. the use of responsibility to insure attainment of the desired goals

c. establishing a project reporting system

d. a continuing process which adjusts the operation to the situation in order to accomplish the desired objective

9. There are various devices for implementing control. Which of the following, if any, is one of these devices?

a. personal observation

b. constant surveillance

c. minimum contact with subordinates

d. none of the above

10. Construction in the theatre of operations differs considerably from ordinary civilian practice. Some of the principal differences involve

a. training, plans, and leadership

b. equipment repair parts and time off

c. time, supply of men and materials, and enemy actions

d. methods of operation and principles of engineering

11. There are many advantages to using troops for construction rather than civilian contractors. Which of the following is NOT such an advantage?

a. economic savings

b. tactical considerations

c. troop construction is more flexible

d. amount and type of equipment

12. Advantages also exist when civilian contractors are employed. One such advantage is that

a. civilian contractors may vary the number and skill level of laborers more readily than the military

b. civilian contractors have better trained personnel

c. civilian contractors do better work

d. civilian contractors cost less

13. A job directive is best described as

a. the plans and specification for a job

b. a work order request

c. a request for equipment. utilization

d. an order to construct, rehabilitate or maintain some facility

14. All job directives contain nine items. Which of the following is NOT found in a job directive?

a. reports

b. mission

c. manpower

d. enemy activity

3

15. In military construction, the planning phase is divided into two stages. They are

a. preliminary and detailed planning

b. intermediate and subordinate planning

c. preoperational and job directive planning

d. none of the above

16. In any site investigation for a proposed project, eight factors should be considered. Which of the following is NOT one of these factors?

a. drainage

b. heliport in the area

c. nature of soils

d. existing facilities

17. A preliminary estimate is made up of five topics. Which of the following is found in a preliminary estimate?

a. supervisors required

b. time required

c. enemy activities

d. project costs

18. When estimating the resources available for a project, the planner must consider

a. manpower and equipment

b. captured enemy equipment available

c. POW's available for labor

d. none of the above

19. When estimating the time required for a project, the planner should base his estimate on the unit's experience records. If these are not available, he may use

a. another unit's experience records

b. published rates in civilian and military texts, modified by knowledge of existing conditions

c. information found in publications from the Defense Records Agency

d. all of the above

20. When planning construction, which item under evaluation can be as important as all others combined?

a. resources available

b. time required

c. climatic considerations

d. construction sequence

SOLUTIONS

LESSON 1..Functions of Management.

Reference: FM 5-333, 1987 ch 1

1.	b (page 1-1)	11.	d (page 1-13)
2.	c (page 1-4)	12.	a (page 1-13)
3.	a (page 1-8)	13.	d (page 1-14)
4.	d (page 1-8)	14.	d (page 1-15)
5.	d (page 1-9)	15.	a (page 1-17)
6.	a (page 1-9)	16.	b (page 1-16)
7.	b (page 1-10)	17.	b (page 1-19)
8.	d (page 1-11)	18.	a (page 1-18)
9.	a (page 1-11)	19.	b (page 1-19)
10.	c (page 1-12, 1-13)	20.	c (page 1-19)

For further explanation, see Discussion.

DISCUSSION

1. Based on recommendations of the theater army engineer (b), the theater army commander establishes construction policies, standards, and priorities in accordance with base development plans.

2. The principles of construction in a TO are speed, economy, flexibility, decentralization of authority, and establishment of priorities. Use of Indigenous personnel (c) is not one of these principles.

3. Planning serves the manager by pointing up the things to be done, their sequence, how long each and a shall take, and who is responsible for what (a).

4. The core of the manager's job in planning is decision-making (d), based on investigation and analysis rather than on snap judgment.

5. The delegation of authority (d) is the key to organization.

6. The engineers, as a supporting service, have problems of construction, often because of limited personnel. Their solutions require planning and coordination of manpower assignments (a).

7. Directing embraces the practical problems of getting personnel to work as a team to accomplish the unit objective Basically, it concerns managing human behavior and taking such action as will improve performance (b).

8. Control is a continuing process which adjusts the operation to the situation in order to accomplish the desired objective (d).

9. Budgeting, statistical analysis, special reports, and personal observation (a) are the devices for implementing control.

10. In a TO, construction differs considerably from ordinary civilian practice. Although the engineering principles involved are unchanged, in combat area operations the factors of time, supply of men and materials, and enemy actions (c) impose a great range of problems.

11. The amount and type of equipment (d) is an advantage of civilian contractors and not an advantage of troop construction.

12. One advantage of using a civilian contractor rather than troops is that the civilian contractor may vary the number and skill level of laborers more readily (a).

13. A job directive is best described as an order to construct, rehabilitate, or maintain some facility (d).

14. A job directive has nine parts: mission, location, time, manpower, equipment, materials, priorities, reports, and special instructions. Enemy activity (d) is not found in a job directive.

15. In military construction, the planning phase is divided into two phases. They are preliminary and detailed planning (a).

16. The eight factors in site investigation are terrain, drainage, accessibility, nature of soils, existing facilities, natural resources, weather, and enemy. Heliport in the area (b) is not one of these factors.

17. A preliminary estimate is made up of five factors. They are materials kind work items involved, resources available to the unit, time required (b), climatic considerations, and construction sequence.

18. When estimating the resources available for a project, the planner must consider manpower and equipment (a).

19. If experience records are not available in a unit, the planner may base his estimate on published rates in civilian and military texts, modified by knowledge of existing conditions (d).

20. When planning construction, climatic considerations (c) can be as important as all other factors combined.

Lesson 2

Critical Path Method (logic and Time Analysis)

Overview

Lesson Description:

This lesson addresses the planning and scheduling process and how these processes will aid managers in accomplishing the mission.

Learning Objectives:

Action: Identify the use and application of the Critical Path Method.

Conditions: Given the material in this lesson.

Standard: Correctly answer all practice exercise questions at the end of each lesson.

Reference: The material contained in this lesson was derived from FM 5-333.

Introduction

Engineer tasks must be managed whether the task is a rear area construction job such as a supply depot, or a forward area combat engineer task such as a barrier minefield. The engineer manager must use a combination of personnel, material and equipment to accomplish the task. These three resources are affected by time, availability of resources, the situation, weather and terrain.

These factors affect both construction planning and combat planning. Bow well the engineer leader accomplishes a task depends largely on the ability to plan, schedule, and control resources within a constrained environment.

LESSON 2

CRITICAL PATH METHOD (Logic and Time Analysis)

CREDIT HOURS..3

TEXT ASSIGNMENT...Chapter 2, FM 5-333

MATERIALS REQUIRED...None.

EXERCISES

Requirement. Solve multiple choice exercises 1 through 30.

1. The critical path method is and sues-formal and graphic means of determining the relationships between tasks associated with any project. Through such a tool the manager can analyze a project

a. before operations only

b. during operations only

c. only if a computer is used

d. before, during, and after operations

2. Before the planner can begin to construct his critical path, he must

a. have access to a computer if there are more than 50 tasks (called Activities)

b. determine those tasks (called activities) which must be accomplished

c. hold a meeting with his subordinates

d. receive permission from the Chief of Engineers to use the method.

3. In order to begin application of the CPM to a project, three simple questions are asked about each task.

These questions, the answers to which will form the logic of the network, deal with

a. precedence, concurrency, and succession of activities

b. cost, duration, and planning of activities

c. size, scope, and number of activities

d. all of the above

4. The network is a graphic portrayal of the relationships between activities throughout the entire project. In drawing a critical path network, each activity is represented by

a. square

b. a rectangle

c. an arrow the tai and head of which represent respectively the start and finish of the activity

d. a triangle

5. The other basic network symbol is a circle which numbers the events. The rule for choosing event numbers is that all numbers used are odd

a. that all numbers used are odd

b. that all numbers used are inclusive

c. that the event number at the head of an arrow must be greater than the event number at the tail

d. events are numbered in the order that they will occur

6. All activity arrows also should be labeled in a second manner. Which of the following is that form of labeling?

a. an individual geometric symbol is assigned to each separate activity; this symbol is coded as the name of the activity

b. the name of the individual in charge is given to each activity

c. each activity is labeled with a cost in dollars which represents the total monetary expenditure for that item

d. the arrow is labeled with the name of the activity it represents

7. In figure 2-1, there is a numbering error. Which of the following responses best describes that error?

a. the event number 2 is never used a network

b. event numbers 7 and 9 should be reversed so that the number at the head of the activity arrow will be greater than the number at the tail of the arrow

c. the event at the head of activity arrow H, 11, indicates completion of the project and is not numbered

d. the event at the head of activity arrow B must be larger than 9.

8. With regard to the CPM network in figure 2-2, which of the following is correct?

a. activities C and E run concurrently

b. activity I must be complete before activity D can begin

c. activity D cannot be complete until activity H is completed

d. activity D cannot be completed until activity C is completed

9. Which of the following is a correct statement about the CPM network in figure 2-2?

a. activity G can begin prior to the completion of activity C

b. activities A and H must start and end at the same time

c. activities A and I can start at the same time

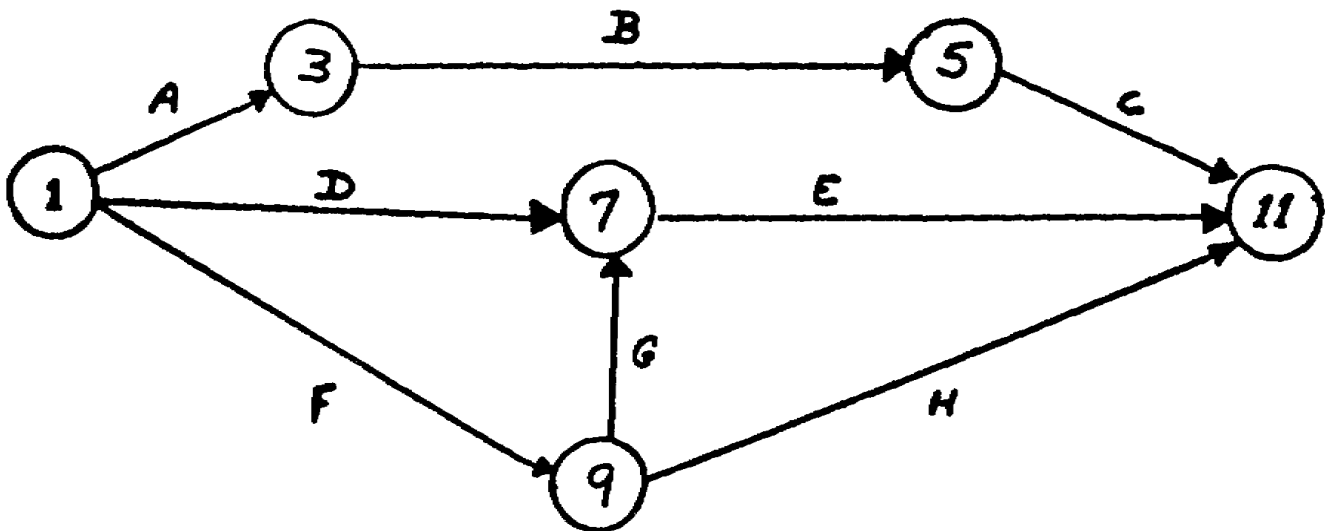d. activity G cannot begin before completion of C, but need not await completion of D

Figure 2-1. For use with exercise 7.

10. Which of the following is a correct statement about the CPM network in figure 2-2?

a. activity D runs concurrently with activity H

b. activities E and F must be completed at the same time

c. activity F can begin before activity H is completed

d. activity C does not run concurrently with activity I

11. When two activity arrows converge upon an event (C and D converge on event 7 in figure 2-2), we know that

a. there is no relationship between activities C and D and activity G

b. only one activity (C or D) has to be completed before activity G can begin

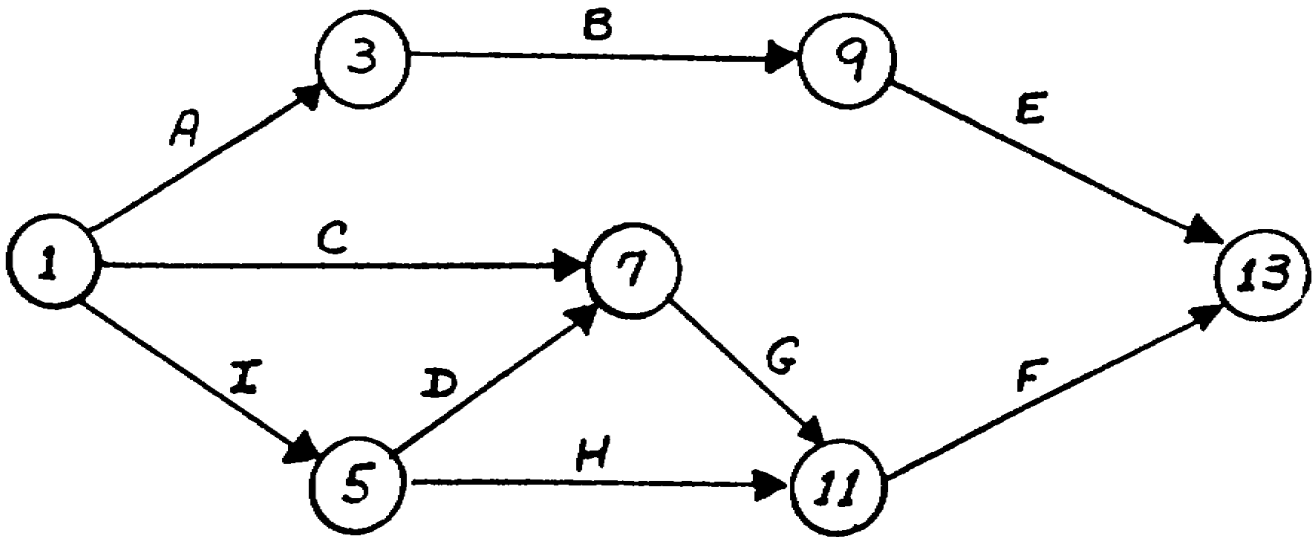c. both activities C and D must be completed before activity G can begin

d. none of the above

Figure 2-2. For use with exercises 8 through 11.

12. Dummy arrows are like any other activity arrows, except that they take zero time, show only relationships,

a. are not represented by an arrow

b. are represented by a dashed rather than a solid arrow

c. are represented by a colored arrow

d. are represented by a double arrow

13. One other use for dummy activities is to eliminate

a. costs

b. arrows

c. events

d. event number duplication

14. Once the network has been drawn, the times required for the completion of the various activities are placed on the appropriate arrows in the network. These times are determined by

a. usual estimating procedures

b. work sampling

c. fixed standards used on every CPM network

d. none of the above

15. Which of the following is not a true statement about a critical path?

a. a critical path may begin or end in the middle of a network

b. a dummy arrow may be on the critical path

c. the project duration is the sum of the durations along the critical path

d. all of the above

16. One would define the Earliest Event Times (EET) as

a. the earliest times the events may be completed

b. the earliest time the entire network can be completed

c. the earliest times thc events may occur

d. all of the above

17. What is the EET for event 5 in figure 2-3?

a. 4   **c.** 7

b. 6   **d.** 11

18. What is the EET for event 8 in figure 2-3?

a. 7   **c.** 14

b. 9   **d.** 16

19. One would define LET (Latest Event Times) as

a. latest times that the events can occur and not delay the project's earliest completion time

b. the latest time that the network will be completed
C EF

c. the latest time an event can be completed

d. none of the above

20. The LET for the ending event is always

a. larger than the EET

b. equal to the EET

c. smaller than the EET

d. none of the above

21. What is the LET for event 10, figure 2-3?

a. 12   **c.** 15

b. 14   **d.** 16

22. What is the LET for event .2, figure 2-3?

a. 3   **c.** 8

b. 6   **d.** 11

23. A critical activity is one which, if delayed by any amount of time, will delay the entire project completion by an equal amount of time. For an activity to be critical, it must meet the specification of three rules. Which of the following is NOT one of these rules?

a. here must be more than three branches (paths) in the network

b. earliest and latest event times of the tail of the activity arrow are equal

c. earliest and latest event times at the head of the activity arrow are equal

d. the EET (or LET) at the head minus the EET (or LET) at the tail is equal to the duration of the activity

24. In the tabulation of activity times, the formula for earliest finish is

a. EF = ES - Dur

b. EF = ES + Dur

c. EF = LF + Dur

d. EF = LF - Dur

25. All activities with a zero total float are

a. nonexistent

Figure 2-3. For use with exorcises 17 through 22.

b. calculated incorrectly

c. activities which precede dummy arrows

d. on the critical path

26. What is the late finish for activity 4-5 (dummy) table 2-1.

a. 5   **c.** 10

b. 6   **d.** 11

27. What is the early finish of activity 7-12? (table 2-1)

a. 14   **c.** 19

b. 17   **d.** 22

28. What is the late start of activity 10-11? (table 2-1)

a. 11   **c.** 15

b. 14   **d.** 16

29. What is the total float for activity 6-8? (table 2-1)

a. 0   **c.** 3

b. 2   **d.** 5

30. What is the total float of activity 4-5? (table 2-1)

a. 0   **c.** 5

b. 2   **d.** 6

Table 2-1. Tabulation Sheet of Network Shown in Figure 323 to Be Used With exercises 26 Through 30

Activity	Duration	Early Start	Early Finish	Late Start	Late Finish	Total Float
1-2	3	0	3	5	8	5
1-3	6	0	6	0	6	0
1-4	5	0	5	6	11	6
1-5	4	0	4	7	11	7
2-4	3	3	6	8	11	5
3-6	4	6	10	6	10	0
4-5	0	6	6	11	—	—
4-7	6	6	12	11	17	5
5-8	3	6	9	11	14	5
6-8	4	10	14	10	14	—
6-10	2	10	12	13	15	3
7-12	5	12	—	17	22	5
8-11	2	14	16	14	16	0
8-12	7	14	21	15	22	1
10-11	1	12	13	—	16	3
11-12	6	16	22	16	22	0

SOLUTIONS

Reference: FM 5-333, 1987 ch 1

1.	d (page 2-3)		16.	c (page 2-11)
2.	b (page 2-5)		17.	b (figure 2-3 of the lesson)
3.	a (page 2-6)		18.	c (figure 2-3 of the lesson)
4.	c (page 2-6)		19.	a (page 2-12)
5.	c (page 2-6)		20.	b (page 2-12)
6.	d (page 2-6)		21.	c (figure 2-3 of the lesson)
7.	b (figure 2-1 of the lesson)		22.	c (figure 2-3 of the lesson)
8.	b (figure 2-2 of the lesson)		23.	a (page 2-13)
9.	c (figure 2-2 of the lesson)		24.	b (page 2-14)
10.	a (figure 2-2 of the lesson)		25.	d (page 2-14)
11.	c (figure 2-2 of the lesson)		26.	d (table 2-1 of the lesson)
12.	b (page 2-9)		27.	b (table 2-1 of the lesson)
13.	d (page 2-9)		28.	c (table 2-1 of the lesson)
14.	a (page 2-10)		29.	a (table 2-1 of the lesson)
15.	a (page 2-14)		30.	c (table 2-1 of the lesson)

For further explanation, see Discussion.

DISCUSSION

1. Through the use of the critical path method, the manager can analyze a project before, during, and after operations (d).

2. Before the planner can begin to construct his critical path, he must determine those tasks (called activities) which must be accomplished (b).

3. The questions which form the logic of the CPM deal with precedence, concurrency, and succession of activities (a).

4. Each activity with a critical path network is represented by an arrow the tail and head of which represent respectively the start and finish of the activity (c).

5. The other basic network symbol is a circle which numbers the events. The rule for choosing event numbers is that the event number at the head of an arrow must be greater than the event number at the tall (c).

6. Activity arrows are either named by the event numbers at the head and tail of the arrow or by the name of the activity it represents (d).

7. The numbering error is in activity G. The direction of the arrow goes from event 9 to event 7. This is incorrect, because the number at the head of the arrow should always be greater than the number at the tail. The error can be most easily corrected by reversing the two event numbers. Choice (b) is correct.

8. Response a is incorrect because no activity going from an event circle can begin until that activity coming into the circle has been completed. Choice b is incorrect for the same reason as stated above.

Response c is incorrect. Although activities D and H begin at the same time, they precede two different events and thus no longer depend upon each other.

Response d is incorrect because activities C and E are entirely separate from each other and do not run concurrently.

9. Response a is incorrect because no activity leaving an event can begin before an activity coming into that event is completed.

Response b is incorrect because activities A and H neither start nor end at the same time.

Choice c is correct because activities A and I begin together at event 1.

Response d is incorrect because both activities C and D must be completed before activity G can begin.

10. Choice a is correct. Both activities D and H start at event 5. They therefore run concurrently.

Response b is incorrect because activities E and F need not be finished at the same time.

Response c is incorrect because no activity starting from a event can begin until the activity ending at that event has been completed.

Response d is incorrect because activities C and I are concurrent in that they begin at the same event.

11. When two activity arrows converge upon an event (C and D converge on event 7 in figure 2-2), we know that both activities must be completed before a third activity (G) can begin (c).

12. Dummy arrows are like any other activity arrows, except that they take zero time show only relationships and are represented by a dashed rather than a sold arrow (b).

13. A second use for dummy activities is to eliminate event number duplication (d).

14. The duration times of various activities are determined by usual estimating procedures (a).

15. If a critical path begins or ends in the middle of the network (a) a mistake has been made.

14

16. Earliest Event Times are defined as the earliest times the events may occur (e).

17. The EET for event 5 is 6 (b. It is derived by adding the duration of the activity (4-5) (which is zero) to the EET at the tail of the arrow (6). $0 + 6 = 6$ (b)

18. The EET is found the same way as in exercise 17; the sum of the duration of activity 6-8, (4) plus the EET at the tail (10). $4 + 10 = 14$ (c)

19. One would define Latest Event Time as the latest time that the events can occur and not delay the projects earliest completion time (a).

20. The LET for the ending event is always equal to the EET (b).

21. The LET is 15. It is derived from subtracting the duration of activity 10-11, (1) from the Let of event 11 (16).

$$16 - 1 = 15(e)$$

22. The LET is 8 (c). It is derived by subtracting the duration from the LET of event 4.

23. The response which is not one of the rules for determining critical path is that there must be more than three branches (paths) in the network (a).

24. The formula for early finish (EF) is: $EF = ES + DUR$ (b).

25. All activities with zero float are on the critical path (d).

26. The LET for activity 4-5 is 11 (d). LET at the tail + DUR = LET at the head. $11 + 0$ (dummy) $= 11$.

27. The early finish is 17 (b). $EF = ES = DUR$
$$EF = 12 + 5 = 17$$

28. The late start is 15 (c). $LS = LF - DUR$
$$LS = 16 - 1 = 15$$

29. The total float is 0 (a). All events on the critical path have zero total float.

30. The total afloat of activity 4-5 is 5 (c). $TF = LS - ES = LF - EF$
$$11 - 6 = 5$$

Lesson 3

Principles of Estimating

Overview

Lesson Description:

This lesson addresses the importance of estimating resources which is necessary to be a good manager.

Lesson Objectives.

Actions: Identify how a manager estimates the resources in man-hours, material, and equipment necessary to complete a project.

Conditions   Given the material in this lesson.

Standard: Correctly answer all practice exercise questions at the end of each lesson.

References: The material in this lesson was derived from FM 5-333.

Introduction

Estimating procedures are designed to yield various results taken from the form of material requirements or bill of materials (BOM) and equipment/personnel requirements. The manager can derive an estimate of the time needed to accomplish each of the tasks in a project.

LESSON 3

PRINCIPLES OF ESTIMATING

CREDIT HOURS...3

TEXT ASSIGNMENT...Chapter 3, FM 5-333.

MATERIALS REQUIRED...None.

EXERCISES

Requirement. Solve multiple-choice exercises 1 through 20.

1. After the preliminary planning stage, succeeding steps in detailed planning depend on

a. valid estimates

b. manpower requirements alone

c. the unit commander

d. analysis of the CPM

2. There are many adverse results of careless estimates. Which of the following is one of those results?

a. failure to meet completion dates

b. uneconomical use of men, materials, and equipment

c. jeopardizing the tactical situation

d. all of the above

3. The estimating process is divided into two separate parts. These are

a. material readiness report and situation reports

b. deadline reports and personnel data reports

c. materials estimate and equipment manpower estimates

d. unit fund reports and blueprint

4. The work items list needed for a material estimate should closely agree with

a. unit deadline rate

b. unit personnel roster

c. no other report, roster, or list

d. CPM activities list

5. When calculating any material estimate, one must plan for waist. Under normal conditions, the waste factor for common construction materials should not exceed in percentage

a. 5 to 10

b. 10 to 15

c. 15 to 20

d. there is no authorized waste whatever

6. Appropriate work rates for the item estimated can be found in

a. battalion S2 files

b. Office of the Chief of Engineers

c. unit personnel records

d. Army manuals, civilian texts, experience, unit records

7. A man-hour is the assign-

a. the amount of effort produced by one man working for one hour

b. the amount of effort produced by two men working for two hours

c. the amount of effort produced by one man working for two hours

d. the amount of effort produced by one man working for one day

8. An efficiency factor is best defined as

a. the amount of work an efficient man can do in a day

b. a measure of the effectiveness of the troops in their situation compared to the standard conditions used in the estimating reference source

c. an excuse to work at less than peak capacity

d. a figure which adds efficiency to a project

9. When one is ordering lumber for a project, you should try to order

a. the exact lengths to fit each item in the plans

b. the longest lengths available

c. any length he desires

d. 8-, 10-, and 12-foot lengths

10. When it is not evident what length of lumber should be ordered for a given project, the estimator should calculate the most economical standard length that when ordered will give the least

a. thickness

b. waste

c. least number of saw operations per piece

d. least number of total pieces

11. You have been given ment of placing a concrete footing that is 180 feet long by 2 feet wide by 8 inches thick. Assuming a 10 percent waste factor, how many cubic yards of concrete will be needed for the project?

a. 8.0   c. 9.8

b. 8.9   d. 10.9

12. Your next project is to backfill a trench which was dug to bury a pipe. The pipe is of such small dimension that its volume is unimportant to your backfilling operation. The trench is 10 feet long, 5 feet deep, and two feet wide. How many cubic yards of fill will you need? (You should allow 10 percent extra fill for compaction.)

a. 3.33   c. 5.00

b. 4.07   d. 5.65

13. During your last road construction project for excavation, loading, and hauling using 18-cubic yard scrapers on a 10-minute cycle, you experienced a production rate of 100 cubic yards per hour. In comparison to the work rate you used which was 11.1 hr/1000 cubic yards, at what efficiency percentage did our scrapers operate?

a. 75   c. 100

b. 85   d. 111

14. You are estimating the manpower requirement to separately form both a concrete footing and a concrete wall, dimensions as shown in the figure on the next page. From TM 5-333 you select a work rate of 14.5 man-hours per 100 SFCS (Square Foot of Contact Surface) for the wall, and 10.0 man-hours per 100 SFCS for the footing. Neglecting the keyway and end forms, what is

your estimate, in man-hours, to construct 25 linear feet of both forms?

a. 63   **c.** 69

b. 66   **d.** 72
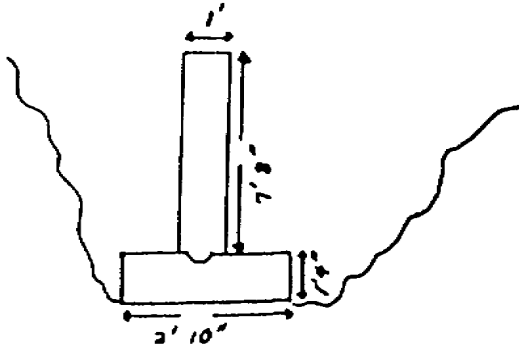
15. A platoon leader estimated that the total effort required to move 3,500 cubic yards of earth using an 18-cubic yard scraper would be 31.5 scraper-hours. He considered his equipment to be operating at 70% efficiency. How many scraper-hours would it have taken to move the same volume of earth at 100% efficiency?

a. 18   **c.** 22

b. 20   **d.** 24

16. Twenty pieces of lumber 2 inches by 4 inches by 30 inches are required. What are the most economical length and the number of pieces to order?

a. 7 pieces of 8-foot lumber

b. 6 pieces of 8-foot lumber

c. 5 pieces of 10-foot lumber

d. 5 pieces of 12-foot lumber

17. 100 pieces of lumber 4 inches by 8 inches by 25 inches long are required. What are the most economical length and number of pieces to order?

a. 35 pieces of 8-foot lumber

b. 30 pieces of 8-foot lumber

c. 25 pieces of 10-foot lumber

d. 20 pieces of 12-foot lumber

18. Your platoon has been given the mission of excavating 350 cubic yards of earth. The battalion S3 tells you that the work rate for excavation with hand tools is 1.75 man-hours per cubic yard. How many man-hours will be required to complete the project if your men work at 70 percent efficiency?

a. 429   **c.** 758

b. 500   **d.** 875

19. You have estimated that a given project will take 760 man-hours to complete. You plan to use 20 men for the project. If you work a 10-hour day, how many days will it take you to complete the project? Any fraction of a day should be considered a full workday.

a. 4   **c.** 6

b. 5   **d.** 7

20. In order to find the duration of a project, you would

a. multiply the crew size by the troop effort

b. divide the total effort by the crew size

c. multiply the work rate by the efficiency

d. divide the work rate by the efficiency

SOLUTIONS

Reference: FM 5-333, 1987 ch 1

1.	a (page 3-1)	11.	c (page 3-3 and 3-4)
2.	d (page 3-1)	12.	b (page 3-5)
3.	c (page 3-1 and 3-2)	13.	d (page 3-3 and 3-4)
4.	d (page 3-1)	14.	a (page 3-5 of the solution)
5.	b (appendix C)	15.	c (page 3-5 of the solution)
6.	d (page 3-3)	16.	c (page 3-5 of the solution)
7.	a (page 3-3)	17.	d (page 3-5 of the solution)
8.	b (page 3-3)	18.	d (page 3-5 of the solution)
9.	d (page 3-4)	19.	a (page 3-5 of the solution)
10.	b (page 3-4)	20.	b (page 3-5 of the solution)

For further explanation, see Discussion.

DISCUSSION

1. Succeeding steps in detailed planning depend on valid estimates (a).

2. Some of the adverse effects of careless estimates were all of the above (d) results.

3. The two parts of the estimating process are materials estimate and equipment/manpower estimates (c).

4. The work items list needed for your material estimate should closely agree with the CPM activities list (d).

5. The waste factor for common construction materials should not exceed 10 to 15 (b) percent under normal conditions.

6. Appropriate work rates for the item being estimated can be found in Army manuals, civilian texts, experience, and unit records (d).

7. A man-hour is the amount of effort produced by one man working for one hour (a).

8. An efficiency factor is best defined as a measure of the effectiveness of the troops in their situation compared to the standard conditions used in the estimating reference source (b).

9. When one is ordering lumber for a project, he should try to use 8-, 10-, and 12-foot lengths (d).

10. When it is not evident what length of lumber should be ordered for a given project, the estimator should calculate the most economical standard length which will give the least waste (b).

11. $180' \times 2' \times \frac{1}{3}' = \dfrac{240 \text{ cu ft}}{27 \text{ cu ft/cu yd}} = 8.9 \text{ cu yd}$

8.9 cu yd + 10% = 9.8 cu yd (c)

12. 5' x 2' x 10' = 100 cu ft loose

100/27 cu ft/cu yd = 3.7 cu yd

3.7 cu yd + 10% = 4.07 cu yd (b)

13. If you moved 100 cu yd of earth per hour, then you would move 1000 cu yd in 10 hours. Your estimate, however, said that it would take 11.1 hours to move 1000 cu yd of earth. If you divide the actual time by the estimated time and multiply by 100%, you will get the actual eficiency percentage.

11.1/10 x 100% = 111% (d)

14. Wall:

25 x 7 2/3 x 2 = 383.3 SFCS

$\dfrac{14.5}{100} = \dfrac{x}{383.3} \quad x = \dfrac{(14.5)(383.3)}{100} = 55.58, \text{ say } 56$

Footing:

25 x 1 1/3 x 2 = 66.7 SFCS

$\dfrac{10}{100} = \dfrac{x}{66.7} \quad x = \dfrac{(10)(66.7)}{100} = 6.67, \text{ say } 7$

56 + 7 = 63 man-hours required (a)

15. x = (31.5) (.70)

x = 22.05 man-hours (c) at 100 percent efficiency

16. 20 pieces of 2 in. 4 in. x 30 in. are needed

8 ft = 96 in.	96/30 = 3+	
10 ft = 120 in.	120/30 = 4	
12 ft = 144 in.	144/30 = 4+	
8 ft	10 ft	12 ft
20 pc/3 pc = 6+ or 7	20 pc/4 pc = 5	20/4 pc = 5
7 x 8 ft = 56	5 x 10 ft = 50	5 x 12 = 60

5 pieces of 10-ft lumber (c) is the most economical length.

17. 100 pieces of 4 inch by 8 inch by 25 inch lumber are required.

```
8 ft  =   96 in.              96/25 = 3+
10 ft = 120 in.              120/25 = 4+
12 ft = 144 in.              144/25 = 5+
8 ft                         10 ft                    12 ft
100/3 = 33+ or 34            100/4 = 25               100/5 = 20
34 x 8 = 272                 25 x 10 = 250            20 x 12 = 240
```

20 pieces of 12-ft lumber (d) is the most economical length.

18. (1.75) (350) = 612.5 man-hours

   612.   5/.70 = 875 man-hours (d)

19. 760/20 = 38 man-hours/1 man

   38/10 = 3.8 day or 4 days (a)

20. In order to find the duration of a project divide the total effort by the crew size (b).

Lesson 4

Scheduling Based on Critical Path Method,
Time and Cost Minimization

Overview

Lesson Description:

This lesson addresses how scheduling based on the critical path method (CPM) requires a formal, detailed investigation into all identifiable tasks that make up the project. This means that the manager must visualize the project from start to finish and must estimate time and resources required for each task.

Lesson Objective:

Action: Identify how to schedule the activities of a project from a critical path network and how to reduce the duration of a project.

Condition: Given the material in this lesson.

Standard: Correctly answer all practice exercise questions tithe end of the lesson.

Reference: The material in this lesson was derived from FM 5-333.

Introduction

As a member of a larger work element, the manager will be responsible for assigned tasks within the CPM network. This requires a better understanding of the total project. Projects are often carried out without consideration of monetary costs. The use of CPM will help the manager to operate within a cost range.

LESSON 4

SCHEDULING BASED ON CPM, AND TIME
AND COST MINIMIZATION

CREDIT HOURS 3

TEXT ASSIGNMENT..Page 2-8 through 2-22, FM 5-333 and
attached memorandum

MATERIALS REQUIRED..None.

ATTACHED MEMORANDUM

4-1. CAUTION IN USE OF SYSTEM

a. Estimating remains the essence of this operation. Estimating, using reasonable resources, should be the rule when preparing the network. If the project duration is greater than can be tolerated, the network should be searched for the tasks that can be shortened by the application of resources from tasks having float.

b. Limited resources may place re-straints that will increase the duration, but most likely in troop construction, where time is the main factor, adjustments can be made that would not be economically reasonable in civilian operations.

4-2. MONETARY COSTS

Theater of operations activities in time of war are often carried out without considera-don of monetary costs. This does not mean, however, that the engineer officer should not be aware of costs or that he will not be called upon to operate within a cost range. It is not at all uncommon to find that troop projects must be funded and kept within a budget. In most instances, costs of normal construction can be very closely estimated and, barring unusual conditions, the job can be kept within. the budget ceiling. It is when time on a job has to be crashed (shortened) that costs are changed. Because of this, it is necessary to have an orderly means of finding out what tasks need to be crashed to reduce a project's duration and which of these, or combination thereof, will cost the least. This is another area in which the critical path method is of great assistance.

4-3. REDUCTION OF PROJECT DURATION

An activity or project will normally have a cost function curve that will be somewhat like that shown in figure 4-1. For every task there is a length of time for accomplishment, Which, associated with a team of men and equipment using a special method, will result in a least cost for the job. Such is repre-sented by the term normal in figure 4-1. This point cannot be considered as the least cost alone because it may not be sufficient to identify the practicable or required time. For
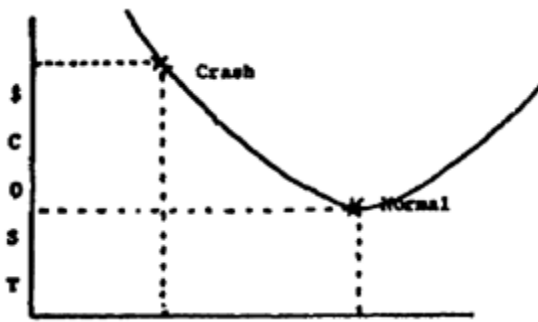
Figure 4-1. Cost function curve.

example, let us consider the plastering of a room which will take one man 80 hours. It is possible to have two working simultaneously with no decrease in efficiency or cost. The duration is now 40 hours. It still requires 80 man-hours but at no additional cost. The normal time for the job is 40 hours; but as we add more men, more equipment, or more expensive equipment, the time is reduced and the cost rises. On the other hand, if an insufficient team is used, time increases as well as cost.

4.4. COST OF COMPRESSION OF TIME

Compression of time of an activity below the normal will cost money. For example, assume that a man digging a hole will take 40 hours. There is room for only one man to work. If he works 8 hours a day, he will take 5 days. Assume he is paid $1.00 per hour; the cost of labor will be $40. It is desirable to expedite the job. Not more than one man can work at a time, so probably it will be necessary to pay overtime for an extra shift. Assume $1.50 per hour for an additional man to work the extra shift. The job will be done in 2 1/3 days, but the cost will now be $48. Say this is not satisfactory. A third man is added and the job is finished in 1 2/3 days. This is the shortest possible time to do this job with manpower and is called the crash point. The cost is now $52. Any further spending of money will be useless because this is the absolute minimum time for this particular method. The crash position on the curve in figure 4-1 represents the absolute minimum time.

4-5. SLOPE

The critical path network planning method of determining costs makes use of the normal cost, the crash cost, the crash time, and the normal time to calculate the cost per unit of time reduction. This last step establishes the cost curve and is known as the slope of the curve joining the normal and crash points. In other words, slope is the cost for time reduction or reduction costing. The slope of the cost curve is obtained by dividing the crash cost minus the normal cost by the normal time minus the crash time. This gives the cost in dollars per unit of time reduction.

$$\frac{\text{Crash cost - Normal cost}}{\text{Normal time - Crash time}} =$$

Cost per unit of time = Slope

This approach is an oversimplification, but for the purpose of this lesson it is sufficient.

4-6. USE OF NET WORK METHOD TO REDUCE COSTS

It may be possible to reduce the time it takes to accomplish a task by increasing the allocation of funds or manpower. The term "normal" refers to the time costing the least in direct cost; the term "crash" refers to the minimum time possible it takes to accomplish a given task associated with a minimum cost for that minimum time. The network method is used as a tool to identify those tasks which should cost the least to reduce in duration either individually or in combinations. The parameters of "crash" and "normal" times for each task in a given project normally give the planner many alternatives from which to select the task(s) that he will reduce to least time for least cost. Selection of a given task or tasks for reduction may result in a different schedule and a different duration time for the project. On the other hand, the combination of tasks selected for reduction may have no effect whatever on the total project duration. This may be desirable in some instances and the manager should be able to identify what he is accomplishing. Certainly this is where the critical path method is of great assistance.

4-7. CHOOSING TASKS FOR REDUCTION

a. **Criteria**. One criterion for choosing a task or tasks for reduction is used on cost. For military purposes where cost is not a factor, the commander may use as his criterion manpower or equipment. For the purpose of this lesson, use the basis of cost. To illustrate the use of the critical path method to reduce a project duration and determine cost, assume that the network shown in figure 4-2 represents a project wherein the time is to be reduced.

b. **Computation**. The project duration in figure 4-2 amounts to 36 time units. Using the information in table 4-1 as it is taken from the network in figure 4-2, review the following problems:

Problem 1. To reduce the project duration by 1 day, consider first that the duration of the project as it stands now is determined by the total of all the task durations on the critical path, which is 2-4, 4-6, and 6-10. Therefore, there is a choice of only these three tasks on the critical path which affect the duration of the project as a whole. It is easy to see that only one job should be reduced, and that is the one on the critical path costing the least per day of reduction: path 6-10 (table 4-1). The project can be reduced by 1 day for only $40 Additional cost.
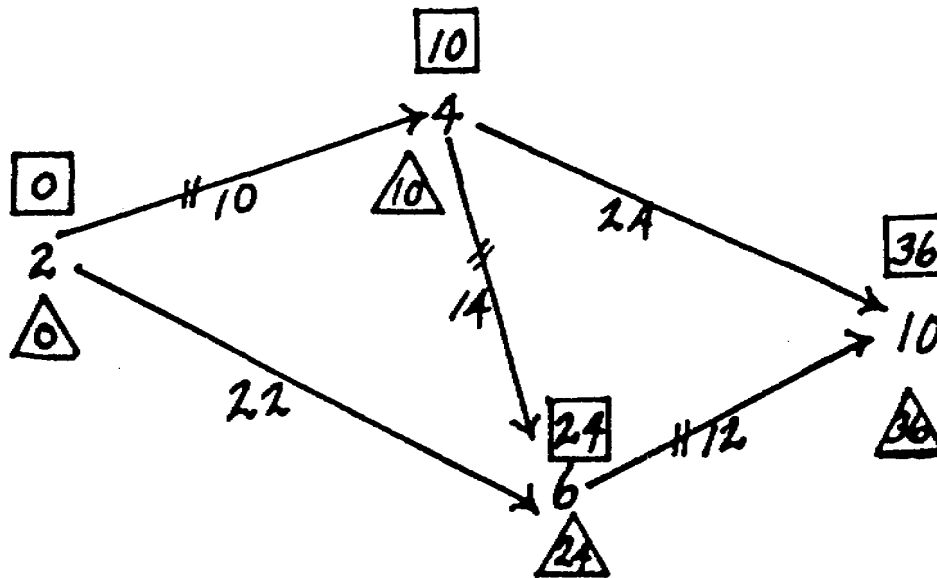

Figure 4-2 Project duration.

TABLE 4-1. *Tabulation of Network in Figure 4-1*

Task	Normal time	Normal cost	Crash time	Crash cost	Slope
2-4	10	$200	9	$300	100
2-6	22	240	18	500	65
4-6	14	280	13	500	220
4-10	24	200	22	250	25
6-10	12	680	8	840	40
		$1,600		$2,390	

Problem 2. Suppose it is desired to reduce the time length of the project by three days. Since problem 1 reduced the task 6-10 from 12 days to 11 days, this means that the project can be reduced by only one more day in the original critical path because further reduction (to less than 34) would change the critical path. By subtracting the crash time from the normal time in table 4-1, it will be seen that path 2-4 can be reduced by 1 day, 2-6 by 4 days, 4-6 by 1 day, 4-10 by 2 days and 6-10 (which has already been reduced by 1 day) by 3 more days. But, if reduction is done according to these figures, it will mean that other paths will become critical. For example, the original critical path had a total duration of 36 days, while the other two possible paths (path 2-4, 4-10 and path 2-6, 6-10) had 34 days each. A way must be found, therefore, by examining all paths and selecting the best combination. The answer is given in figure 4-3. Path 2-4, 4-10 is reduced by 1 day; path 2-4, 4-6, 6-10 is reduced by 3 days; and path 2-6, 6-10 by 3 days. Table 4-2 shows the results in cost
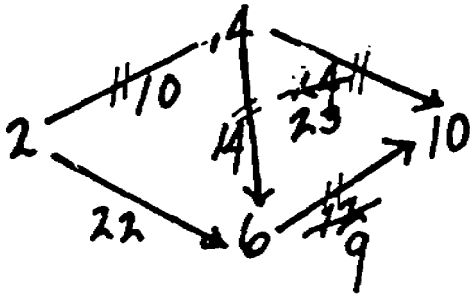

Figure 4-3. *Reduction of duration.*

Table 4-2. *Tabulation of Reduction*

Activity	Cost	Duration
2-4	$200	10
4-10	225	23
2-6	240	22
4-6	280	14
6-10	800	9
	$1,745	

Problem 3. To get the job done in the minimum time possible and at the least cost, the question here is: Which path will govern the least time? The answer is that path 2-4-10 governs (fig 4-4) because it is minimum possible time even on crash basis. Therefore, any reduction below 31 days for any of the other paths is a waste of money. Table 4-3 shows the cost.
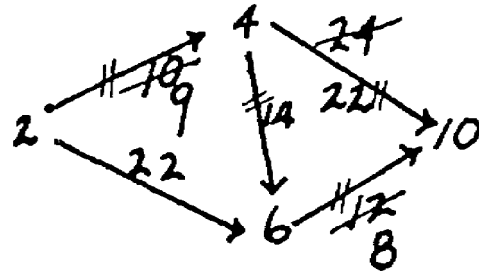

Figure 4-4. Reduction to minimum time and eat cost.

Table 4-3. *Tabulation of Cost*

Activity	Cost	Duration
2-4	$300	9
2-6	240	22
4-6	280	14
4-10	250	22
6-10	840	8
	$1,910	

c. Needless crashing. In the past it has been common practice to crash everything and thus spend money for no return in time saved. If each task in this network had been crashed, $480 would have been spent needlessly. It should be easy to see that manpower may be wasted in troop construction unless the controlling tasks are identified and only the amount of labor is applied that is needed to meet the critical path requirements. When the minimum time has been reached With the least cost in manpower, and further allocation of such resources returns no further reduction in time, it is useless to add more men or machines.

First requirement: Solve multiple-choice exercises 1 through 16 which pertain to the principles of scheduling.

1. What s the first step in constructing a CPM schedule?

a. measure the total float for each activity

b. add up the total duration of the activities and divide by the number of activities

c. mark on the schedule the time span during which each activity may be performed without delaying the project or violating any of the network sequence relationships

d. determine the total monetary expenditure for the first five activities

2. What is the time span during which activity 7-12 may be performed in figure 4-5?

a. days 12 through 17

b. days 13 through 22

c. days 16 through 22

d. days 17 through 22

3. What is the time span during which activity 5-8 may be performed in figure 4-5?

a. days 4 through 14 scheduled

b. days 5 through 11

c. days 7 through 14

d. days 10 through 14

4. Activity 8-12 has a time span of days 15 through 22 (fig 4-5). What would the consequence be if it were to begin prior to day 15?

a. there would be no serious consequences

b. activity 8-11 would have to be scheduled early also

c. activity 11-12 would have to be delayed

d. There would be a violation of the network logic since activity 8-12 would be starting before activity 6-8 was completed

5. What would the consequence be if activity 7-12 was not completed until day 23 in figure 4-5?

a. activity 11-12 would have to be delayed

b. activity 4-5 would have to be completed ahead of schedule

c. activity 8-11 would have to be dropped from the network

d. the entire project would be delayed

6. How does the planner indicate where a particular activity is scheduled?

a. the duration of the activity is placed on the line for each day the activity is scheduled

b. the number of men in the crew is placed on the line for each day the activity is scheduled

c. the number of pieces of equipment needed for the activity is placed on

d. there is no way to indicate when a particular activity is

7. What is the duration in days of activity 5-8 in figure 4-6?

a. 2   **c.** 8

b. 3   **d.** 9

8. The blank spaces on the line figure 4-6) to the right of the number represents the time along the line on which one can place the activity and still not delay the project completion. It is called
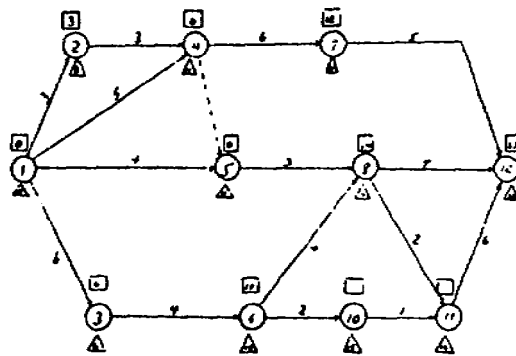
Figure 4-5. For use, with exercises 2 through 5.

a. duration   c. schedule time

b. total float   d. activity length

9. Activity 5-8 in figure 4-6 could have been scheduled any time between days 6 and 14. It was scheduled to be performed as soon as possible. When all activities are performed in this manner, the schedule is called

a. early start schedule

b. early finish schedule

c. least duration schedule

d. maximum efficiency schedule

10. That part of total float, if it is moved into, will cause another activity to be interfered with is called

a. duration float

b. negative float

c. interfering float the schedule

d. scheduled time

11. Dummy activities take no time. Therefore, they are

a. listed on a separate schedule

b. scheduled with colored ink

c. not scheduled

d. listed at the bottom of the schedule

12. On an early start schedule, interfering float is indicated by

a. circles   c. triangles

b. X's   d. nothing

13. An efficient way of identifying the manpower required for all the activities in progress on any given day is to

a. add the crew sizes vertically on the schedule

b. ask the platoon sergeant

c. refer to the estimating tables in FM 5-333

d. add the crew sizes horizontally on

14. An accurate CPM time analysis depends upon

a. controlling   c. crashing

b. programming   d. estimating

Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14
5 - 8						2	2	2						

Figure 4-6. For use with exercises 7 through 9.

29

15. Committing more equipment, manpower, and materials to a project and extending the work hours are all means of

a. decreasing the cost

b. increasing efficiency

c. decreasing the duration

d. eliminating a CPM

16. Computers can be used for CPM scheduling. They are significantly faster than manual computations for time analysis of any network with over how many activities?

a. 10   c. 50

b. 30   d. 100

Second requirement. Solve multiple-choice exercises 17 through 20 which pertain to minimization of time and cost.

17. You are instructed to dig a trench for a water pipe. You have estimated that the normal time duration for the project is 22 hours and that it will cost $240. The battalion commander desires that the trench be completed in 18 hours. You estimate that in order to save four hours the total cost of digging the trench will increase to $500. Calculate the cost per hour of time saved (slope).

a. 65   c. 80

b. 75   d. 125

18. Which method is correct for determining which activity(s) will be crashed when the network duration is to be shortened.

a. crash only float activities

b. crash each activity equally

c. crash selected activities that will not alter the critical path, but keep increased costs to a minimum, yet shorten the duration of the network

d. crash random activities

19. You have estimated that it will take a platoon 6 days to construct a 20-foot by 80-foot building to be used as battalion headquarters. The project will cost $2000. You must reduce the project duration by two days. The crash cost will be $3000. What is the cost per day for the time saved?

a. 500   c. 1000
b. 750   d. 1500

20. As we add more men and equipment to a job, we can expect the duration to decrease and the cost to -

a. reduce slightly   c. increase

b. remain the same   d. reduce greatly

30

SOLUTIONS

LESSON 4...Scheduling based on Cfm, Time and Cost Minimization.

Reference: FM 5-333, 1987 ch 1 and attached memorandum

1.   c (page 215)

2.   b (figure 4-5 of the solution)

3.   c (figure 4-5 of the solution)

4.   d (figure 4-5 of the solution)

5.   d (figure 4-5 of the solution)

6.   b (page 2-19)

7.   b (figure 4-6 of the lesson)

8.   b (figure 4-6 of the lesson)

9.   a (figure 4-6 of the lesson)

10.   c (page 2-19)

11.   c (page 2-8)

12.   b (page 2-18)

13.   a (page 4-9 of the solution)

14.   d (page 4-9 of the solution)

15.   c (page 2-21)

16.   c (page 2-21)

17.   a (memorandum para 4-5)

18.   c (memorandum para 4-5)

19.   a (memorandum para 4-5)

20.   c (memorandum para 4-3)

For further explanation, see Discussion.

DISCUSSION

1. The first step in constructing a CPM schedule is to mark on the schedule the time span during each activity may be performed without delaying the project or violating any of the network sequence relationships (c).

2. The time span during which activity 7-12 may be performed is days 13 through 22 (b). Day 13 is the first day after the completion of activity 4-7. Day 22 is the late finish at the head of the activity arrow.

3. The time span is days 7 through 14 (c).

4. If activity 8-12 started before day 15 there would be a violation of the network logic, since activity. 612 would be starting before activity 6-8 was completed (d).

5. If activity 7-12 was not completed until day 23 the entire project would be delayed (d) by one day.

6. The planner indicates when a particular activity is scheduled by placing the number of men in the crew on the line for each day while activity is scheduled (b).

7. Activity 5-8 has a duration of 3 (b) days. It is derived by counting the number of blocks in figure 4-6 which have the crew size (2) in them.

8. The blank spaces to the right of the number represents total float (b).

9. When all activities are scheduled to be performed as soon as possible, the schedule is called an early start schedule (a).

10. Interfering float (c) is defined as that part of the total float which, if it is moved into, will cause another activity to be interfered with.

11. Dummy activities are not scheduled (c).

12. On an early start schedule, interfering float is indicated by X's (b).

13. An efficient way of identifying the manpower required for all the activities in program on any given day is to add the crew sizes vertically on the schedule (a).

14. Accurate CPM time analysis depends upon estimating (d).

15. Increasing the amount of equipment, manpower and materials and extending the work hours are al means of decreasing the duration (c).

16. Computers are significantly faster for time analysis for any network with over 50 activities (c).

17. Slope = cost per unit time

$$\text{Slope} = \frac{\text{crash cost - normal cost}}{\text{normal time - crash time}}$$

$$= \frac{500 - 240}{22 - 18} = \frac{260}{4} = \$65 \text{ (a)}$$

18. To determine which activities will be crashed one should crash selected activities that will not alter the critical path and keep increased costs to a minimum, yet shorten the duration of the project (c).

19. Slope = cost per unit time

Slope = crash cost - normal cost

$$\text{Slope} = \frac{\text{crash cost - normal cost}}{\text{normal time - crash time}}$$

$$= \frac{3000 - 2000}{6 - 4} = \frac{1000}{2} = \$500 \text{ (a)}$$

20. As we add men and equipment to a job, we can expect the duration to decrease and the cost to Increase (c).

Lesson 5

Site Layout

Overview

Lesson Description:

This lesson addresses the importance of a site layout, the arrangement of the facilities and personnel required to carry out a project.

Lesson Objective:

Action: Identify how to plan an efficient layout of a construction project.

Condition: Given the material in this lesson.

Standard: Correctly answer all practice exercise questions at the end of the lesson.

Reference: The material in this lesson was derived from FM 5-333.

Introduction

Site layout is the arrangement of the facilities and personnel required to carry out a project. It is one of the most important phases of construction engineering. The objective is to plan the physical arrangement of the site so that the construction process is carried out as efficiently as possible.

LESSON 5

SITE LAYOUT

CREDIT HOURS...3
TEXT ASSIGNMENT...Chapter 4, FM 5-333
MATERIALS REQUIRED..None.

EXERCISES

Requirement. Solve the following multiple. choice exercises.

1. Which of the following is not an influencing [actor in plant layout.

a. natural topography

b. required facilities

c. prefabrication

d. size of the project

2. The major reason for prefabrication is

a. cheaper cost

b. need for less equipment

c. reduced construction time and substitution of general labor for skilled labor

d. standardizes the methods and materials used

3. A time-motion study aims at increasing efficiency of a project by

a. reducing the project's critical path

b. reducing the number of unskilled laborers assigned to the project

c. reducing the time and effort expended on any repetitive process

d. reducing the waste of critical materials.

4. A planner, that details the processing of each type of material, indicating what takes place, the time required, and how far it must be moved, is utilizing a

a. flow diagram

b. now process chart

c. layout plan

d. all of the above

5. Standard symbols used on the flow diagram and flow process chart have been adopted for military use. A square is the symbol for

a. inspection   **c.** transportation

b. delay   **d.** storage

6. The now process chart is used in the study of an actual or proposed process. In the flow process chart for cutting rafters (fig 4-5 FM 5-333) ,how

many seconds are consumed by transportation?

a. 5   c. 9

b. 7   d. 15

7. In the flow process chart for cutting low chords (fig 4-l0 FM 5-333) if one changes the time for making the first cut from 2 seconds to 6 seconds, what important effect would it have on the computations?

a. change the control factor from 4 to 6

b. change the control factor from 4 to 8

c. add a delay factor of 4 seconds

d. change the time from 30 seconds to 32 seconds for the process

8. Why is the unit rate (table 4-23 FM 5-333) for cutting rafters the lowest of all the truss parts?

a. rafters are larger and harder to handle than are other parts

b. rafters need more cuts than do the other parts

c. rafters have to be moved more frequently than do the other parts

d. the control factor for cutting rafters has the longest time interval

9. Using 12 men, what is the number of man-hours required to cut 24 trusses for one building?

a. 3.20   c. 6.54

b. 5.46   d. 7.49

10. On the first day, cutting of the members for 489 trusses is begun. Cutting time is proportional for the nine 50-minute hours of the 10-hour working day. For how many trusses will you have parts at the end of the first day?

a. 325   c. 397

b. 376   d. 414

11. The 2-inch by 6-inch lumber (fig 4-3 item 4, FM 5-333) can be supplied in 10-foot lengths only. Truss dimensions remain unchanged. (630 trusses are needed.) What effect will this have on the total cutting Lime.

a. increase by 34 minutes

b. increase by 45 minutes

c. increase by 66 minutes

d. remain the same

12. The second step in determining a control factor is

a. refer to the appropriate estimating table in FM 5-333

b. list all operations and the time required for each

c. determine those which are performed concurrently

d. divide the total time necessary to produce one end item by the number of operations

13. How does a planner eliminate traffic tie-ups when designing a plant?

a. the layout of the plant should be balanced

b. material delivery schedule should be made to eliminate on-the-job storage

c. one-way roads or turnabouts are used

d. material flow should be arranged so that it may be helped by gravity

14. When should materials be delivered for an efficient plant operation?

a. as frequently as possible so as to minimize on-the-job storage

b. at the outset of the project so that the work cannot be delayed by lack of materials
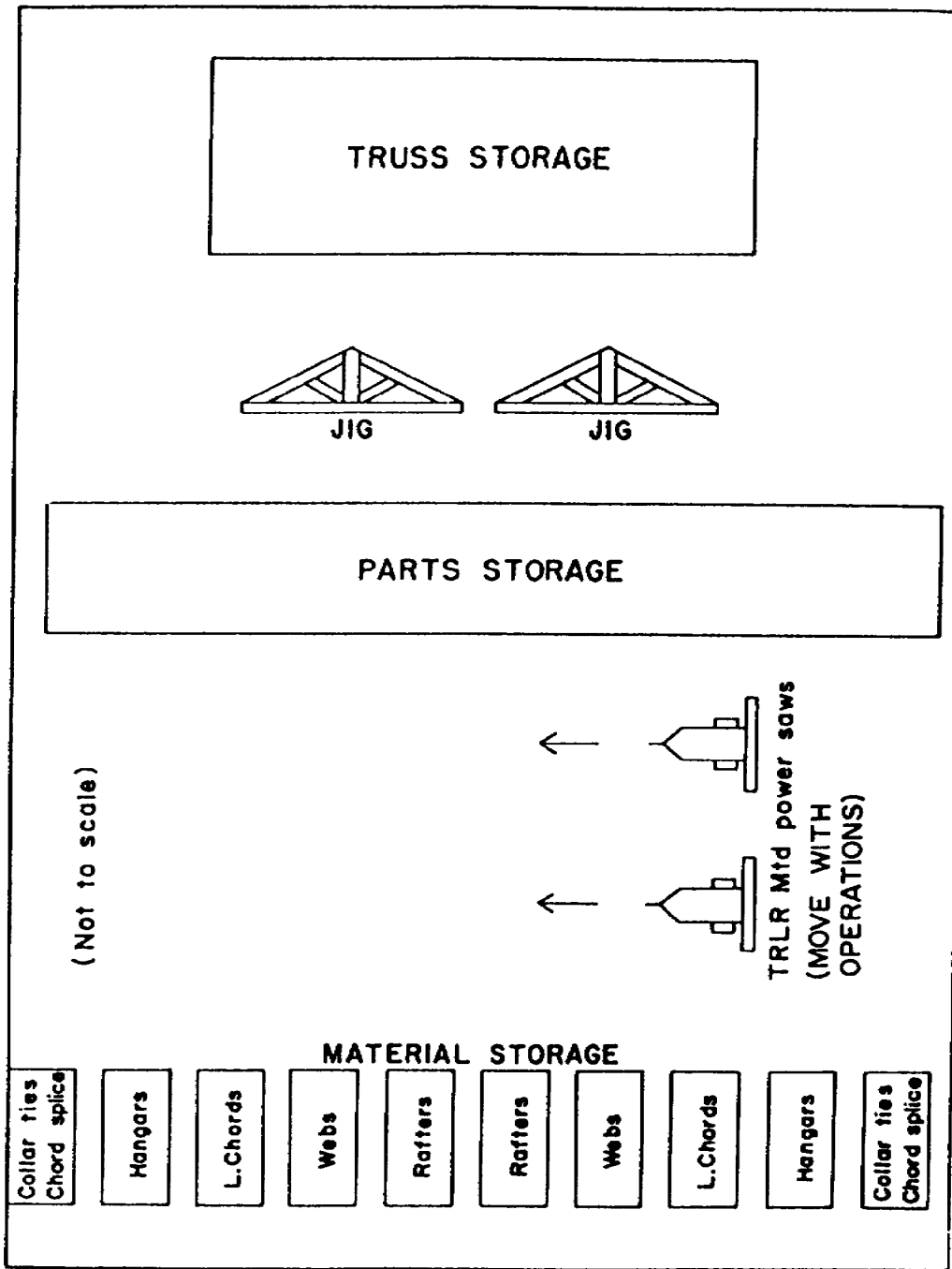
c. once each month

d. the first day of every work week

Figure 5-1. First trial layout. (For use with exercise 16)

15. Where possible, material flow within the plant should be arranged so that it may be aided by

a. equipment

b. gravity

c. indigenous personnel

d. railroad transportation

16. The methods analysis system may be used as a means of improving an existing layout. Figures 5-1 and 5-2 show two plant layouts for cutting and assembling trusses. For what reason is figures 5-2 more efficient than figure 5-1?

a. the saws are nearer the truss storage area in figure 5-2

b. a larger parts storage area is available in figure, 5-2

c. the jigs are nearer the parts storage area in figure 5-2

d. figure 5-2 does not require movement of the saws

17. Figure 5-3 shows a better plant layout for cutting and assembling trusses than does figure 5-2. Why is this so?

a. the saws are closer to the truss storage area in figure 5-3

b. parts storage and assembly facilities are greater in figure 5-3

c. the conveyor is longer in figure 5-3

d. figure 5-3 has a third saw

18. Plant layout as described in FM 5-333 is particularly valuable because it provides

a. the estimator with extremely reliable material upon which to base his plans

b. the estimators of the project with a reliable alternative to CPM scheduling

c. greater coordination between the estimator and supervisor than does the usual method

d. the project supervisor with less work to do

19. The flow process chart provides a means of analyzing each operation and movement of material to determine

a. what, how, where, and when each operation is performed

b. who will work on the project

c. the cost of the project

d. the duration of the project

20. Which of the following procedures would facilitate the handling and cutting of the rafters to the best advantage?

a. two handlers to carry the rafters to the first saw

b. only one saw will be used; the second saw man will aid the first

c. four handlers to remove the rafter from the conveyor

d. one handler to troop the rafter to the saw and a second handler to assist the first saw man

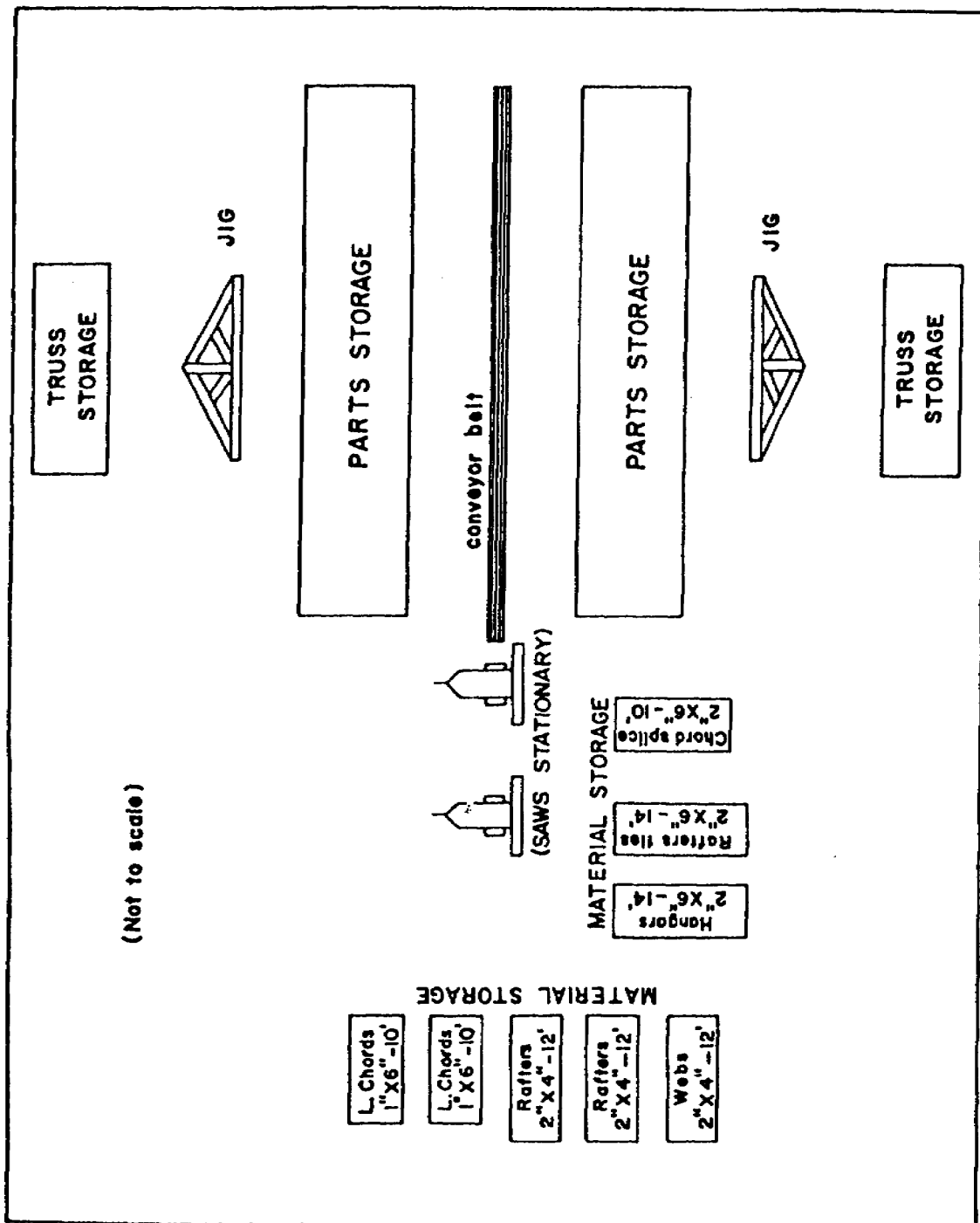*Figure 5-2. Second trial layout. (For use with exercises 16 and 17)*

Figure 5-3. Third trial layout. (For use with exercise 17)

SOLUTIONS

Reference: FM 5-333, 1987 ch 1

1.	c (page 4-2 and 4-3)	11.	b (figure 4-8)
2.	c (page 4-3)	12.	c (page 4-2)
3.	c (page 4-5)	13.	c (page 4-21)
4.	b (page 4-6)	14.	a (page 4-20)
5.	a (figure 4-1)	15.	b (page 4-21)
6.	d (figure 4-5)	16.	d (figure 5-1, 5-2 of the solution)
7.	b (figure 4-10)	17.	b (figure 5-2, 5-3 of the solution)
8.	d (table 4-2)	18.	c (page 4-24, FM 5-333)
9.	d (table 4-2)	19.	a (page 5-8 of the solution)
10.	d (table 4-2)	20.	d (page 5-8 of the solution)

For further explanation; see Discussion.

DISCUSSION

1. Prefabrication (c) is not an influencing factor in plant layout.

2. The major reason for prefabricated construction is the reduced construction time and substitution of general labor for skilled labor (c).

3. A time-motion study aims at increasing efficiency of a project by reducing the time and effort expended on any repetitive process (c).

4. The purpose of flow process charts (b) is to detail the processing of each type of material, indicating what takes place, the time required. and how far it must be moved.

5. A square is the symbol used to indicate inspection (a).

6. Adding the number of seconds for each transportation action we get, 5 (No. 2) + 4 (No. 7) + 6 (No. 10) = 15 seconds (d) total.

7. The control factor would change from 4 to 8 (b) since the first cut is not a concurrent operation and therefore increase the total time by 4 seconds.

8. The unit rate (table 4-2 FM 5-333) for cutting rafters is the lowest of all the truss part because the control factor for cutting rafter has the longest time interval d).

9. From table 4-2 total production time = 86.7

Production time to cut parts for one truss: $\frac{86.7}{4000} = .02167$

Convert to man-hours: $\frac{.02167}{5} \times 6 \times 12 = .312$

.312 x 24 truss = 749 (d)

10. Number of truss units cut per hour = 46.1 (from table 4-2

46. 1 x 9 = 414.9 or 414 (d)

11. From figure 4-8 Control factor changes to $\frac{15}{2}$ or 7.5 sec

Production rate $= \frac{60 \times 50 \times .70}{7.5} = 280$ Truss/hr

Hanger cutting time $\approx \frac{630}{280} = 2.25$ hours

Original cutting time: $\frac{630}{420} = 1.50$ hours

2.25 - 1.50 = + .75 hrs -- + 45 Min (b)

12. In determining the second step in control factor one must determine those which are performed concurrently (c).

13. Traffic tie-ups should be avoided by use of one-way roads or turnabouts (c).

14. For an efficient plant operation, materials should be delivered as frequently as possible so as to minimize on-the-job storage (a).

15. Material flow within the plant should be arranged so that it may be added by gravity (b).

16. The plant layout shown in figure 5-2 is more efficient than that in figure 5-1 because the saws in figure 5-2 do not require movement (d).

17. Figure 5-3 portrays a better plant layout than does figure 5-2 because the parts storage and assembly facilities are greater in figure 5-3 (b).

18. Plant layout described in the text is particularly valuable because it provides greater coordination between the estimator and supervisor than does the usual method (c).

19. The flow process chart provides a means of analyzing each operation and movement of materials to determine what, how, where, and when each operation is performed (a).

20. The most efficient procedure for handling and cutting rafters is to employ one handler to carry the rafter to the saw and a second handler to assist the first saw man (d).

Lesson 6

Controlling Functions

Overview

Lesson Description:

This lesson addresses the steps in the supervision process and how you control job progress.

Lesson objective:

Action: Identify the three steps in the supervision process and how to control job progress in construction operations through effective supervision.

Condition: Given the material in this lesson.

Standard: Correctly answer all practice exercise questions at the end of the lesson.

Reference: The material in this lesson was derived from FM 5-333.

Introduction

As a supervisor you will direct and control subordinates, that is, telling people what to do, then make sure they do it. The three steps in the supervision process are to set objective standards, measure performance and make adjustments.

LESSON 6

CONTROLLING FUNCTIONS

CREDIT HOURS..2

TEXT ASSIGNMENT...Chapter 5, FM 5-333

MATERIALS REQUIRED...None.

EXERCISES

Requirement. Solve the following multiple-choice exercises.

1. Supervision is defined as

a. delegating authority

b. establishing a schedule of frequent inspection and reports to insure the project is completed

c. planning for unforeseen problems

d. telling subordinates what to do, then making sure they do it

2. There are three steps in the supervision process. Which of the following is NOT one of these steps?

a. measure performance against standards

b. set objective standards

c. insure standards are rigid

d. make adjustments where performance does not meet standards

3. Written communication for supervision includes communications devices designed for a downward flow of orders from supervisor to subordinate. Which of the following are examples of these devices?

a. regulations, SOP's, directives, and policy memoranda

b. bills of materials and work order requests

c. report

d. materiel readiness reports and unit deadline reports

4. Oral communication is valuable in that it provides an opportunity for exchange of information on a personal basis. One characteristic of oral communtion is

a. inflexibility

b. immediate feedback

c. large administrative effort

d. time loss

5. There is a tendency to overuse written communications. To avoid this, regulations, SOP's, directives, policy memoranda, and reports should be ex-

amined to determine which are obsolete and which might be better handled orally. This should be done at least every

a. 3 months   c. 9 months

b. 6 months   d. 12 months

6. The control device which gives the command firsthand knowledge of the situation and provides for immediate feedback is

a. inspections

b. reports

c. tours

d. monthly briefings

7. Unannounced inspections are used to

a. bring the unit up to a specified performance level

b. catch the unit in an unprepared state

c. measure the units normal performance

d. insure the unit is working

8. Inspections are a valuable tool used to teach, guide, and compel things to happen as planned. Commanders, however, are often too busy to inspect frequently. They most often solve this problem by

a. making infrequent but thorough inspections

b. delegating other work and spending a great deal of time on inspections

c. permitting subordinate units to inspect themselves

d. delegating inspection authority

9. An inspection checklist is frequently used by the inspector to insure that all pertinent areas of interest are observed. Of the following, which category is not included on an inspection checklist?

a. quality of construction

b. utilization of resources

c. projects belonging to another unit

d. maintenance

10. When inspecting the construction aspects of a project, the inspector is most interested in

a. comparing the construction progress with the CPM schedule

b. having all activities ahead of the CPM schedule

c. the police of the project

d. avoidance of criticism, constructive or otherwise

11. When one inspects the utlization of resources, he is most interested in

a. cost, maintenance, and construction

b. men, equipment, and materials

c. indigenous personnel

d. transportation, safety, and security

12. When lack of time makes inspections by the commander impossible, what control devices are used as supplements?

a. use of indigenous personnel

b. time-motion studies

c. systems analysis

d. reports from subordinates

13. A good reporting system is valuable in that it

a. eliminates the need for inspections but still provides the commander with all of the required information

b. subordinates know what is important by the nature of the reports they must submit

c. provides the commander with a con-

tinuous flow of valuable information
at considerable time savings

d. indicates who is not doing his job
properly

14. Reports are a control device.
They should never be used as a means of

a. setting standards or policy

b. informing the higher commander

c. transmitting information

d. management

15. There are three types of re-
ports commonly used .when supplying
information concerning a project. They
are production reports, budget reports,
and schedules. A budget report com-
pares

a. actual and planned expenditures

b. materials ordered with those con-
sumed

c. profits and expenditures

d. equipment productivity with dead-
line rates

16. A detailed CPM schedule can be
used

a. to report the percentage of comple-
tion of the project
project by U. S.

b. compute the float overruns

c. as a materiel readiness report

d. as a construction control device

17. Use of indigenous personnel can
be advantageous in that

a. they save money for the U. S. tax-
payer

b. they have an ingenuity in working
with readily available materials

c. their employment aids the economy
of their country

d. their work is superior to that of mili-
tary engineers

18. When employing indigenous
personnel, one should use a local super-
visor because he will

a. save money

b. save time

c. facilitate control of the other local nationals

d. save materials

19. Any civic action project should
be designed for

a. minimum community involvement

b. maximum community involvement

c. no military involvement

d. accomplishment without U. S. as-
sistance

20. Which of the following results
from a good civic action project?

a. use of the completed

forces.

b. need for further projects is mini-
mized

c. local community looks to U. S. for
additional help and support

d. local skills are developed

Reference: FM 5-333, 1987 ch 1

1.	d (page 5-1)		11.	b (page 5-6)
2.	c (page 5-1)		12.	d (page 5-7, 5-8)
3.	a (page 5-2)		13.	c (page 5-7, 5-8)
4.	b (page 5-3)		14.	a (page 5-8)
5.	b (page 5-4)		15.	a (page 5-8)
6.	a (page 5-5)		16.	d (page 5-8, 5-9)
7.	c (page 5-4)		17.	b (page 5-10)
8.	d (page 5-4)		18.	c (page 5-10)
9.	c (page 5-5)		19.	b (page 5-11)
10.	a (page 5-4)		20.	d (page 5-11)

For further explanation, see Discussion.

DISCUSSION

1. Supervision is defined as telling people what to do, then making sure they do it (d).

2. The three steps in the supervision process are to set objective standards, to measure performance against standards, and to make adjustments where performance does not meet standards. Insuring that while standards are rigid (c) is not one of the steps.

3. Examples of written communication for a downward flow of orders from supervisor to subordinate are regulations, SOP's, directives, and policy memoranda (a).

4. One characteristic of oral communication is Immediate feedback (b).

5. To avoid the overuse of certain written supervisory communications, they should be examined at least every six months (b) to find which regulations, SOP's, directives, policy memoranda, and reports are obsolete and which would be better suited for oral communication.

6. The control device which gives the commander firsthand knowledge of the situation and provides for immediate feedback is inspections (a).

7. Unannounced inspections are used to measure the unit's normal performance (c).

8. When a commander finds that he is too busy to inspect frequently, he finds that the purposes of inspections can best be accomplished by delegation of Inspecting authority (d).

9. The categories of an inspection checklist are construction, utilization of resources, maintenance, health and welfare, police, and other inspection checkpoints. Projects belonging to another unit (c) are not found on the checklist.

10. When inspecting the construction aspects of a project, one is most interested in comparing the construction progress with the CPM schedule (a).

11. When one inspects the utilization of resources, he is interested in men, equipment, and materials (b).

12. When there is insufficient time to inspect, reports (d) should be used as supplements.

13. A good reporting system is valuable in that it provides the commander with a continuous flow of valuable information at considerable time savings (c).

14. Reports, which are a control device, should never be used as a means of setting standards or policy (a).

15. A budget report compares actual and planned expenditures (a).

16. A detailed CPM schedule can be used as a precise construction control device (d).

17. Indigenous personnel arc a benefit to the construction engineer unit in that they have an ingenuity in working with readily available materials (b).

18. A local supervisor should be used when employing indigenous personnel because he will facilitate control of the local nationals {c).

19. Any civic action project should be designed for maximum community involvement (b).

20. One characteristic of a good community action project is the development of local skills (d).